

Computerized Decision-Making in the Pulmonary Function Laboratory

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Computers are now in widespread use in pulmonary function laboratories, where they have made an important contribution by assisting with complex and repetitive tasks. They can be used to acquire data from testing instruments, make measurements and calculations, and prepare reports. At LDS Hospital in Salt Lake City, we use the HELP (Health Evaluation through Logical Processing) Computer System for medical decision-making. As a result of our experience with this system, we have found six definable steps between data acquisition and data interpretation: (1) establish quality instrumentation, (2) establish adequate procedures for test performance, (3) standardize measurement and computational techniques, (4) determine the adequacy and reproducibility of results and apply a test selection, (5) identify the measurements to be used for interpretation, and (6) apply strategies that lead to consistent interpretation of results. Because spirometry and blood gas tests account for the major activities of our pulmonary function laboratory, we have applied these six steps necessary for computer decision-making to these two tests; however, they are equally applicable to other tests in the pulmonary function laboratory. (Gardner RM, Crapo RO, Morris AH, Beus ML. Computerized Decision-Making in the Pulmonary Function Laboratory. *Respir Care* 1982;27:799-808. Key words: Blood gas analyzers, Computers, Diagnosis, computerassisted, Information processing, computer, Respiratory function tests, Respiratory therapy.)

INTRODUCTION

Because most of the clinical decisions in the pulmonary laboratory are based on quantitative laboratory tests, it seems logical that computers be used in the decision-making process. This article describes the application of computer technology to decision-making and outlines the strategies needed to make the computer an effective decision-making tool.

THE APPLICATION OF THE COMPUTER TO THE PULMONARY FUNCTION LABORATORY

Background

The LDS Hospital in Salt Lake City, Utah, is a 550-bed tertiary care referral center. Automation of the pulmonary function laboratory was begun in 1968 with the telecommunications of spirometric results,¹ and the development of computer methods has progressed to the present time. The major emphasis in recent years has been on the standardization of equipment and techniques, the generation of reference values, and the development of decision-making rules. During 1981 our pulmonary function laboratory performed more than 62,000 blood gas analyses and 1,116 pulmonary function tests, and a presurgical screening laboratory performed 5,376 spirometry tests. Unlike several other computer systems, by which data are automatically or semi-automatically gathered and reported in tabular form, our system and techniques use the computer for medical decision-making. The system is called HELP, an acronym for Health Evaluation through Logical Processing.² Early in our application of computers to the medical field, it became apparent that the mere display of numbers and the formulation of reports by the computer, although useful, did not justify the computerization

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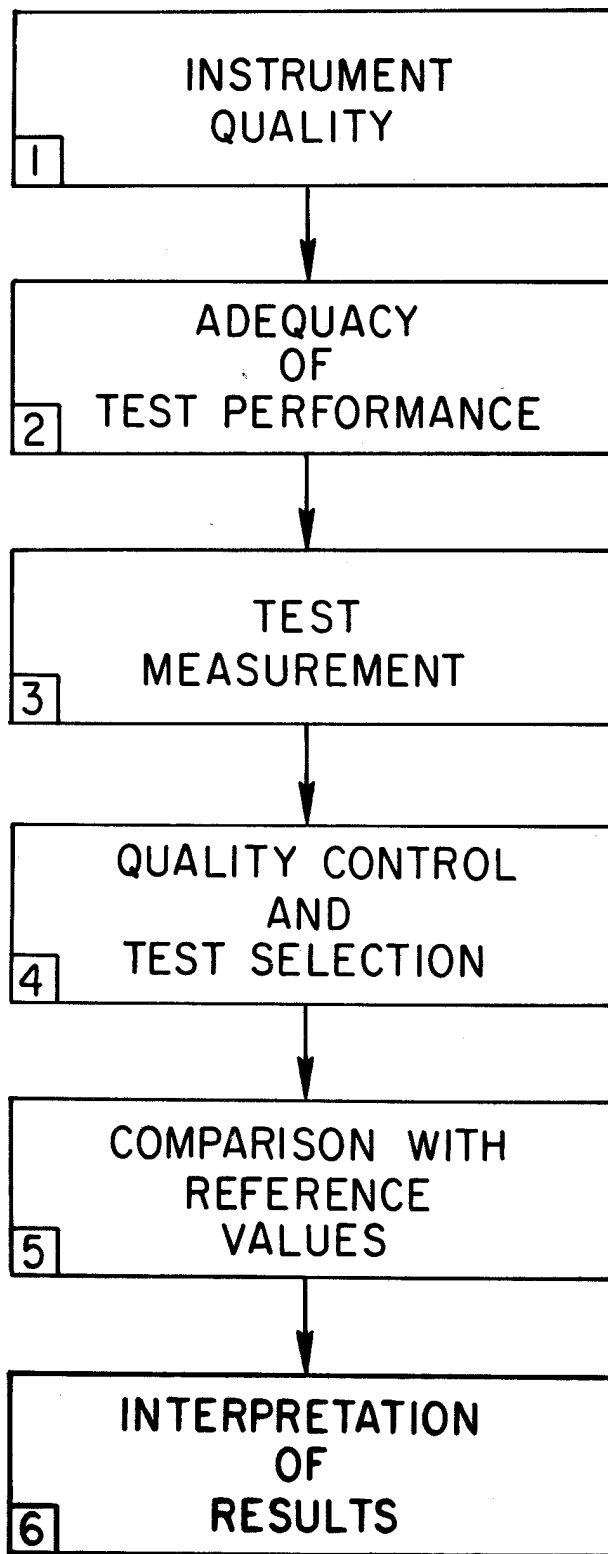


Fig. 1. Six considerations used in the pulmonary function laboratory from data acquisition to data interpretation.

of the hospital's clinical functions. Subsequently, we began to investigate the possibilities of applying the computer to the important tasks of interpreting the results of individual tests (eg, spirometry) and combinations of tests (eg, spirometry and lung volume tests).

We found that six crucial steps were required between data acquisition and data interpretation (Fig. 1). For the interpretation to be correct each step had to be carefully specified. An initial attempt at this specification was the publication of a standardization manual by the Intermountain Thoracic Society (ITS).³ As a result of our computer and clinical experience, six definable steps between data acquisition and interpretation became crystallized. The six steps are (1) to establish quality instrumentation; (2) to establish adequate procedures for test performance; (3) to standardize measurement and computational techniques; (4) to determine the adequacy and reproducibility of results and to apply a best-test selection; (5) to identify the measurements to be used for interpretation so that they can be compared with reference values; and (6) to apply strategies that lead to consistent interpretations of results.

Because spirometry and blood gas tests account for the major activities of pulmonary function laboratories, we have applied the six steps to these two tests; however, the outlined procedures are equally applicable to other tests in the pulmonary function laboratory.

Spirometry Data

The forced expiratory spirogram has the most clearly defined reference values and is the most widely understood and the most easily applied routine test of lung function.^{4,5} The application of the six steps to spirometry data is made as follows:

1. *Instrument Quality.* The American Thoracic Society (ATS)⁶ and the American College of Chest Physicians (ACCP)⁷ have recently recommended minimum performance requirements for spirometry. Commercially available spirometers have been subjected to these recommendations,⁸ and as a result, spirometer instrumentation has improved.

2. *Test Performance.* The ATS, at its Snowbird Workshop,⁶ and the ITS³ have outlined requirements for the assessment of the quality of the forced vital capacity maneuver's test performance.

3. *Test Measurement.* Standardized methods of test measurement have been recommended by the ATS⁶ and the ITS.³ These include the back extrapolation technique for determination of “time zero” and the conversion of expired volumes to BTPS (body temperature and pressure, saturated with water vapor).

4. *Assessment of Quality Control and Test Selection.* The ATS⁶ has suggested methods for evaluating the patient’s performance during spirometry, because a lack of adequate patient effort is still the single largest source of error in spirometry. Adequate patient performance can best be elicited by a well-trained, motivated, and enthusiastic technician. After adequate test results have been obtained, one must decide which data to use. The ATS⁶ has made recommendations; however, more recent results⁹ show that a single best test (largest sum FVC and FEV₁) provides a simple yet accurate assessment of the patient.

5. *Comparison of Selected Results with Reference Values.* Once one has obtained reliable data from the patient, using the above techniques, results should be compared with an appropriate reference population.^{10,11} These reference values are generally derived from linear regression equations in which age, height, and sex are used as independent variables. There is still no universal agreement on which reference values should be used, especially when children and different ethnic groups are studied. For adult Caucasians, however, their data’s consistent agreement with the predicted values reported in the excellent studies of Morris *et al*¹⁰ and Crapo *et al*¹¹ will establish one or both of these studies as the source of the most commonly used reference values.

6. *Strategies That Lead to Consistent Interpretation of Results.* There exists considerable uncertainty about how to use reference values to determine whether a spirogram is normal or abnormal.^{3,12-19} The most common method in current use is the fixed per cent method, in which $\pm 20\%$ of the predicted value is assumed to be normal. However, the fixed per cent method has no sound scientific basis, and recent publications favor the use of 95% confidence intervals (CI).^{11,14,20} We have found the 95% confidence interval to be almost constant in spite of age and height variations¹¹ (eg, one 95% CI for FVC for males is 1.111 and for females is 0.68 1). Using the 95% CI method, then, we can classify chest restriction. The same conceptual framework and the FEV₁/FVC% are used to classify airway obstruction. The 95% CI for FEV₁/FVC% for females is 9.06% and for males is 8.28%. Using the statistical approach of taking 95% confidence intervals and multiples to categorize severity of disorder, we then established the criteria shown in Table 1.

Table 1. Categorization of Airway Obstruction, Using 95% Confidence Intervals (CI)

Category	Predicted Value Minus Measured Value	
	Women FEV ₁ /FVC%	Men FEV ₁ /FVC%
Normal (<1 CI)	<9.1	<8.3
Mild (1 to 2 CI)	9.1 to 18.0	8.3 to 16.5
Moderate (2 to 4 CI)	18.1 to 36.1	16.6 to 33.0
Severe (≥ 4 CI)	≥ 36.2	≥ 36.2

Using the male patient data shown in Figure 4 as an example, one determines the predicted value for FEV₁/FVC% as 76.9. The measured FEV₁/FVC% prebronchodilator is 50.9. The predicted value minus the measured value is 26.0: thus, the patient falls into the moderate airway obstruction category as indicated in Figure 4.

This decision-making practice has been extended to other pulmonary function tests,²¹ the results of which will be reported in the near future. The degree of inconsistency in the interpretation of pulmonary function tests is not surprising, as there is such variability in each of the six steps.¹³ The computer is unable to perform magic; it must be programmed with detailed and specific criteria in order to make valid decisions.²²

Blood Gas Test Data

Tests that measure blood gases have dramatically enhanced the physician's ability to detect and treat ventilation and perfusion disorders. Commercial blood gas machines became available in the early 1960s, and subsequent technology has enabled these instruments to provide rapid and reliable results. Almost all commercially available instruments now contain microcomputers, which relieve the technician of the major work load and of the necessity to perform manual calibrations.

Although a somewhat different situation exists for the interpretation of blood gas data than for those of spirometry, the same six steps must still be applied:

1. *Instrument Qualify.* To assess the quality of blood gas machines, multiple-point and single-point calibration must be performed at regular intervals; this is necessary because of electrode instability and the potential for contamination of the electrodes by the blood being measured. A variety of aqueous fluorocarbon- and hemoglobin-based control standards are now available commercially. Tonometers may also be used to provide blood samples for calibration purposes.

2. *Adequate Test Performance.* Much has been written in recent years about the correct drawing, mixing, handling, transport, and storage of blood samples. All these tasks must be performed adequately or errors in clinical decision-making will result.²³⁻²⁵

3. *Test Measurement.* With the advent of computerized systems, test measurements are now made automatically. With computerized systems, however, extreme care must be practiced in handling samples and recording results.

4. *Quality Control and Test Selection.* As with clinical laboratories, blood gas laboratories will soon be required to implement strict quality-control measures.^{26,27} The California Thoracic Society²⁸ has recently implemented a blood gas proficiency testing program that is now being applied nationwide by the American Thoracic Society (ATS) and the College of American Pathologists (CAP).²⁹

5. *Comparison of Results with Reference Values.* Because a blood gas analysis includes multifactorial measurements, the analysis of each result on a simple high-low basis is not very helpful. Recent studies have been done on normal subjects to determine reference values.³⁰ A more common method of interpreting pH and Pco₂ is to apply an acid-base map, a map of hydrogen ion concentration vs Pco₂ (Fig. 2). This map, which allows easy graphical determination of bicarbonate (HCO₃⁻) and preliminary classification of simple acid-base disorder,^{31,32} is currently in wide use.

6. *Interpretation of Results.* Interpretations fall into five major sections: (1) determination of acid-base status from the acid-base map pH and Pco₂; (2) determination of oxygenation and oxygen-carrying-capacity status from the Po₂, hemoglobin, and oxygen saturation; (3) comparison of most recent results with older values to assess change (eg, determination of whether hypoventilation has been corrected, by measurement of the change in Pco₂); (4) calculation and reporting of derived values (eg, right-to-left shunt and O₂ consumption); and (5) alerting for life-threatening conditions.

The final interpretation depends upon the patient's clinical condition and must be made by the physician caring for the patient. As with spirometry, the interpretation of blood gas results cannot be made in isolation but must be integrated with other information (eg, clinical laboratory data, respiratory therapy data, chest radiograph results, drugs given, clinical status, and physical findings).

COMPUTERIZED DECISION-MAKING: CLINICAL EXAMPLES

Because of the complicated and repetitive nature of many measurements performed, computers of all sizes, including programmable hand-calculators, have been applied to the pulmonary function laboratory and have aided us dramatically in dealing with complexity. We have established a hospital-wide computer system, which integrates patient data from many sources, including the pulmonary function laboratory (Fig. 3). This system, called HELP, provides the intercommunication of information among 18 computers located in such areas of the hospital as the clinical laboratory and intensive care units (ICU). An example of the function of this system is

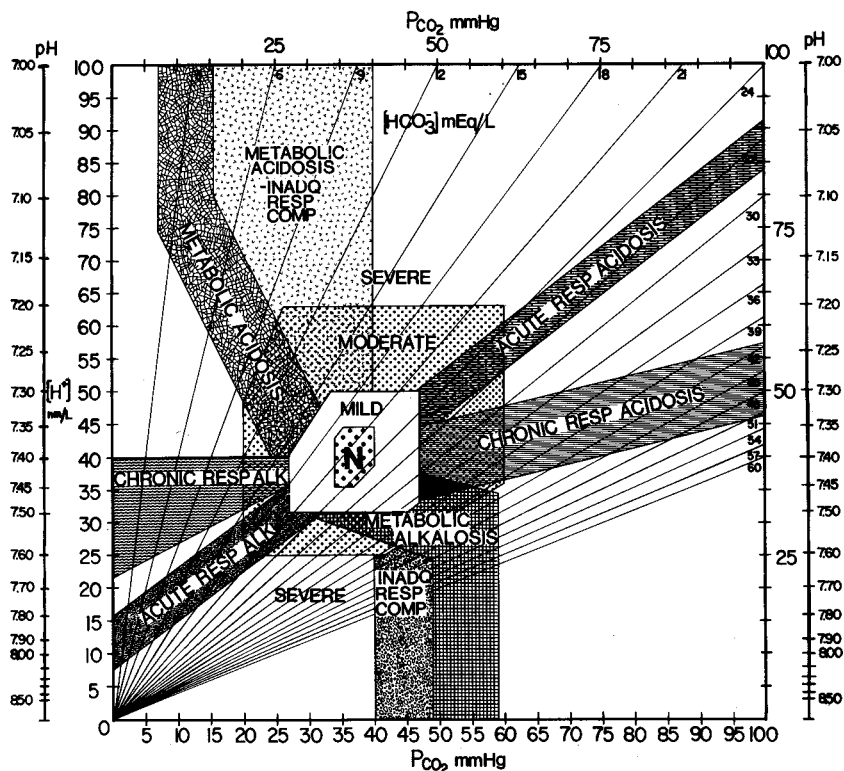


Fig. 2. Acid-base map (H^+ vs P_{CO_2} plot) used by the computer to interpret patient acid-base status.

provided when blood gas information for an ICU patient is entered into the computer system by the pulmonary function laboratory personnel and the results are immediately printed in the ICU and are available for review at any terminal in the hospital. The HELP computer system also provides computerized patient data for the medical staff members and thereby assists them in making clinical decisions. It also allows us access to data from other laboratories; eg, when we have an acid-base abnormality in the blood gas results, we can review recent related data from the clinical laboratory, such as anion gap, BUN, lactate levels, and glucose ketone bodies.

The computerized decision logic is stored on a magnetic disc and is easily modified and updated. Included in the decision-writing tools provided by the HELP system are (1) a powerful, yet easy-to-use system for selecting desired patient data; one uses key words for access to the data and provides a complete series of time constraints about the data; (2) a complete set of arithmetic, Boolean, and Bayesian operations to allow all types of decision rules to be developed; (3) a message scheme that allows efficient yet complex statements to be easily generated; and (4) a data-base management system that permits rapid access to patient and decision data for review and reporting.

Examples of the types of reports issued from the computer-generated decisions are given in Figures 4 and 5 for pulmonary function and blood gas analyses.

Pulmonary Function Testing

Pulmonary function testing in our laboratory consists primarily of spirometry measurements, carbon monoxide diffusing capacity measurement, and lung volume measurement by helium dilution, plethysmographic, and x-ray techniques. Figure 4 is an example of a computer-generated pulmonary report. First is the spirometric interpretation, which shows that there is moderate airway obstruction and that the obstruction did not clearly improve following administration of a bronchodilator. This patient's lung volumes are normal, but his diffusing capacity is severely reduced. All these computer-generated decisions are based on criteria formulated by the Intermountain Thoracic Society (ITS).³ The decision criteria were originally

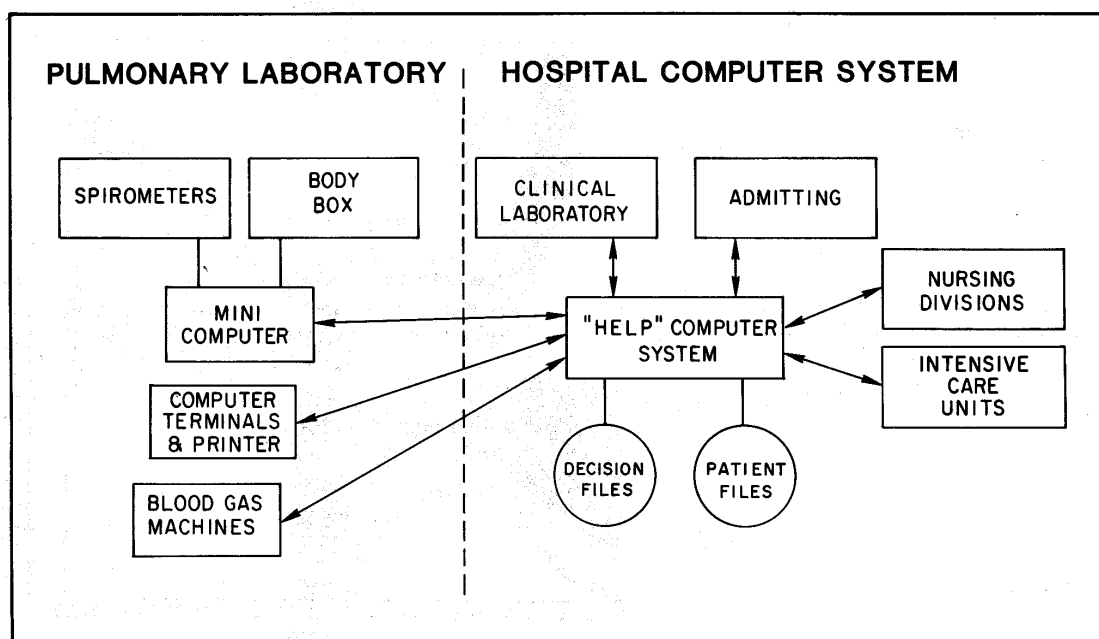


Fig. 3. Block diagram of HELP computer system showing how instruments, terminals, laboratories, and nursing divisions are interconnected. Also shown are the patient and decision disc files.

established during an open discussion by a panel of pulmonary physicians, and the criteria have been continually updated since that time. Some of the initial criteria from the ITS were in error and some had no scientific basis. The computer-generated reports prospectively provided a data base upon which improved criteria were evaluated.²¹ Our decision-making criteria are continually being updated and refined. This interactive process has facilitated development based upon observation and data analysis. We hope to ultimately use the computer interactively in making diagnostic and therapeutic decisions by use of all the patient's information.

Blood Gases

The blood gas laboratory is a complex and busy clinical operation. For results to be reliable, the drawing of samples and the reporting of results must be prompt. The HELP system provides assistance to the blood gas laboratory because the ordering and reporting of tests are performed by means of the computer. As soon as samples are drawn they are taken to a central laboratory and are analyzed. Results from the analysis of the blood are promptly entered into the computer by a technician using a keyboard. Because two instruments are used for

each sample (blood gas machine and a CO-Oximeter) and because programs resident in the microprocessors of our instruments are not exactly what we want, direct interface of the machine output to the computer has not yet been found to be efficient. During the data-input process, results are compared with reasonable values, tested for internal consistency, and displayed to the operator for verification. Once the results are verified, the

LDS HOSPITAL PULMONARY FUNCTION REPORT										
DARWIN			NO.		49019		CASE 10865		RM DSCH JAN 29 82	
SEX: M	AGE: 75	HT: 171	WT: 61.80	DR		KENNETH BP 645 TEMP 22.0				
		PRE-BRONCHODILATOR				POST-BRONCHODILATOR			% IMPR	
JAN 29	PRED	95%CI	08:14	PRED-MEAS	%PRED	08:37	PRED-MEAS	%PRED		
FVC (L)	4.01	1.12	2.65	1.36	66	2.69	1.32	67	2	
FEV .5 (L)	2.54		0.92	1.62	36	0.99	1.55	39	8	
FEV 1 (L)	3.06	0.84	1.35	1.71	44	1.48	1.58	48	10	
FEV1/FVC%	76.9	8.3	50.9	26.0	66	55.0	21.9	72		
FEV 3 (L)	3.60	1.02	2.19	1.41	61	2.40	1.20	67	10	
FEV3/FVC%	90.5	4.6	82.6	7.9	91	89.2	1.3	99		
FEF 25-75%	2.77	1.67	0.67	2.10	24	0.84	1.93	30	25	
EX TIME (SEC)			6.18			4.84				
JAN 29 08:43										
25% 02										
	PRED	95%CI	MEAN	PRED-MEAS	%PRED					
DLCO SB	28.1	8.2	5.4	22.7	19					
DL/VA SB	4.46	1.4	0.88	3.58	20					
TLC SB (L)	6.50	+/-1.61	6.15	0.35	95					
FRC SB (L)	3.46	+/-1.46	4.59	-1.13	133					
RV SB (L)	2.41	+/-0.76	3.81	-1.40	158					
RV/TLC SB	0.37		0.62	-0.25	168					
VC SB (L)	4.01	1.12	2.35	1.66	59					
IC SB (L)				1.57						
ERV SB (L)				0.78						
HB SB (MG/DL)				14.4						
	PRED	95%CI	MEAN	PRED-MEAS	%PRED					
JAN 29 08:57										
TLC PL (L)	6.50	+/-1.61	7.00	-0.50	108					
INTERPRETATION TIME: JAN 29 82 09:20										
MODERATE AIRWAY OBSTRUCTION										
SPIROGRAM NOT CLEARLY IMPROVED POST BRONCHODILATOR										
NORMAL TLC AND FRC - FROM PLETHYSMOGRAPHIC LUNG VOLUMES										
SUGGESTION THAT AIR TRAPPING PRESENT										
ESTIMATED TRAPPED AIR 0.85 L (PL - SB)										
SEVERELY REDUCED DIFFUSING CAPACITY (DLCO)										
EFFORT MAY BE SUBMAXIMAL (HE DILUTION VC LESS THAN FVC)										
DLCO DECREASE DUE TO ALTERED GAS EXCHANGE SURFACE (REDUCED DL/VA)										
95%CI - IS 95% CONFIDENCE INTERVAL (LOWER LIMIT OF NORMAL=(PRED-95%CI) ;										
+/- INDICATES 2 SIDED 95%CI, OTHERWISE 1 SIDED 95%CI)										

Fig. 4. Computerized Pulmonary Function Report. At the top are patient identification and categorization information and spirometry test results prebronchodilator (08:14 hrs) and postbronchodilator (08:37) (PRED = Predicted, 95% CI = 95% Confidence Interval, % IMPR = % Improvement.) The FVC and other spirometric measures are then given along with expiration time, EX TIME (SEC). Next are the single breath (SS) diffusing and lung volume results (08:43). The last data item is the plethysmographic lung volume, TLC PL (08:57). The final part of the report is the computer-generated interpretations.

computerized decision-making aspect of the HELP computer is initiated. In approximately 30 seconds the blood gas variables and their interpretations (Fig. 5) are available for review. Reports are printed at the specific nursing division where the patient is located, and results can be reviewed on any of the 175 terminals located throughout the hospital.

The blood gas report demonstrates many features of the decision-making process. At the top of Figure 5, the most recent set of a patient's arterial and mixed venous blood gases is shown. The patient is on 100% oxygen and intermittent mandatory ventilation (IMV). The acid-base status shows a pattern of moderately acute respiratory acidosis. The arterial P_{CO_2} (48.2) is now elevated but was normal (41.3) at 06:00 hours, resulting in the message "HYPOVENTILATION (PREVIOUSLY NORMAL)." A urine glucose of 4+ from an ICU charting entry suggests diabetic ketoacidosis. This entry demonstrates how other data sources, such as the ICU or clinical laboratory (eg, the anion gap), can contribute to data interpretation. An estimate of oxygen consumption is made by applying the Fick principle and by the knowledge that the cardiac output (CO) was 5.29 l/min within 15 minutes of 09:40, when the blood samples were drawn. The arterio-venous oxygen content difference (AVO₂) and the hemoglobin (HB) value used are reported and the A-a gradient (A-A) is calculated. The per cent right-to-left shunt (R-TO-L SHUNT) (44%) is estimated from the CaO_2 , the CvO_2 , and the $C\bar{c}O_2$ (calculated) from the PAO₂ and the hemoglobin (averaged arterial and mixed venous). Note that in the 06:00 and other interpretations, the alerting mechanism, "CONTACT MD OR RN," is activated, which advises the staff that a life-threatening situation exists.

The blood gas data acquisition, communication, and reporting schemes have been enthusiastically accepted by nurses and physicians alike. A survey conducted a few years ago by Battelle Laboratories (Columbus OH), an independent evaluation group, revealed a very positive attitude toward the computerized spirometry and blood gas analysis system among our staff physicians. They feel that the computerized blood gas interpretation is particularly effective in helping the physician make decisions and diagnoses and in adjusting therapy. Most physicians think that the interpretations save them a great deal of time and they value the service. Physicians have high expectations of the computerized pulmonary and blood gas laboratory and indicate that the system meets their expectations 81% of the time. These highly positive evaluation ratings have stimulated further refinements of the computerized pulmonary and blood gas systems.

DISCUSSION/CONCLUSION

One of the key factors affecting the success and acceptance of the HELP computer system has been the ease with which physicians and nurses can review data. In general, very little data entry is required of the physician or nurse; technicians, pharmacists, and other health care professionals do most of the input procedures.

The computerized decision-making practices discussed here are based on the large HELP computer system; however, some of the principles can also be applied to smaller microcomputer systems, and even to programmable pocket calculators. It is interesting to note that use of computers has forced physicians to make consistent decisions about the acquisition, measurement, selection, and interpretation of laboratory results. Because the computer cannot deal with nebulous criteria, physicians in our region have established very direct and quantitative criteria that can be entered into the computer, thereby resulting in decisions with which there is general agreement. The computer is thus forcing medicine to be more quantitative. Basic advantages of our computerized decision-making technique are (1) a consistent and high quality of data acquisition; (2) a consistent and high quality of decision-making; (3) standardized measurement procedures; (4) the elimination of almost all measurement and computational errors; (5) the provision of a valuable tool to train attending physicians and house staff in the interpretative process; (6) the rapid availability of data and reports; (7) the automatic construction of data files for subsequent statistical evaluation; (8) the availability of derived variables (right-to-left shunt, O₂ consumption, A-V O₂ differences) that are not convenient to produce by manual methods; (9) the integration of all patient information to facilitate high-level decisions; and (10) the

L D S H O S P I T A L B L O O D G A S R E P O R T

FEB 03 82	ESTHER E	NO. 61534 DR	DANIEL	RM 5N79
NORMAL HI	PH 7.45	PCO2 40.0	HCO3 25.0	BE 2.5
NORMAL LOW	7.35	34.0	19.0	-2.5
		13.0		13.0
		0/ 1	85	95
		68	93	17.4

03 09:41 V	7.28	52.3	24.0	-3.0
03 09:40 A	7.29	48.2	22.7	-3.9
		13.1		13.1
		1/ 1	70	93
		14.2	100	32/ 25/ 0
		12/ 0		

SAMPLE # 51, TEMP 35.2, BREATHING STATUS : IMV
MODERATE ACUTE RESPIRATORY ACIDOSIS
HYPOVENTILATION (PREVIOUSLY NORMAL)
CONSIDER DIABETIC KETOACIDOSIS (URINE: GLUCOSE 4+,KETONES 0+)
O2 CONSUMPTION 176 ML/MIN - CO 5.29 L/MIN
AV O2 CONTENT DIFF 3.32 (HB 13.25) O2 EXTRACT RATIO 2%
R-TO-L SHUNT 44%+/-3%
A-A GRADIENT 482, A/A 13% (EST ALV PO2 552)

03 06:01 V	7.35	45.8	24.9	-0.5
03 06:00 A	7.37	41.3	23.5	-1.1
		12.5		12.5
		1/ 1	49	84
		12.2	40	26/ 22/ 6
		11/ 0		

SAMPLE # 50, TEMP 35.6, BREATHING STATUS : IMV
MILD ACID-BASE DISORDER
O2 CONSUMPTION 163 ML/MIN - CO 5.93 L/MIN
AV O2 CONTENT DIFF 2.75 (HB 12.60) O2 EXTRACT RATIO 2%
R-TO-L SHUNT 52%+/-3%
A-A GRADIENT 144, A/A 25% (EST ALV PO2 193)
SEVERE HYPOXEMIA **CONTACT MD OR RN!!!!

03 01:43 V	7.36	48.3	26.9	1.3
03 01:42 A	7.39	42.7	25.5	1.0
		13.5		13.5
		1/ 1	55	86
		13.3	41	29/ 23/ 6
		11/ 0		

SAMPLE # 49, TEMP 36.4, BREATHING STATUS : IMV
MILD ACID-BASE DISORDER
O2 CONSUMPTION 209 ML/MIN - CO 6.27 L/MIN
AV O2 CONTENT DIFF 3.33 (HB 13.65) O2 EXTRACT RATIO 2%
R-TO-L SHUNT 45%+/-3%
A-A GRADIENT 144, A/A 28% (EST ALV PO2 197)
SEVERE HYPOXEMIA BREATHING OXYGEN **CONTACT MD OR RN!!!!

02 22:25 A	7.44	35.3	23.8	0.9
		14.1		14.1
		1/ 0	58	89
		17.5	41	32/ 26/ 6
		10/ 0		

SAMPLE # 48, TEMP 37.1, BREATHING STATUS : IMV
NORMAL ARTERIAL ACID-BASE CHEMISTRY
ESTIMATED R-L SHUNT 73,46,33% (AT AV DIFF OF 0.90, 2.90, 4.90)
A-A GRADIENT 147, A/A 28% (EST ALV PO2 205)
SEVERE HYPOXEMIA BREATHING OXYGEN **CONTACT MD OR RN!!!!

02 21:11 V	7.45	37.1	25.6	2.6
02 21:10 A	7.47	35.5	25.7	3.2
		13.7		13.7
		2/ 1	49	85
		13.8	41	30/ 23/ 4
		10/ 0		

SAMPLE # 47, TEMP 36.9, BREATHING STATUS : IMV
MILD ACID-BASE DISORDER
AV O2 CONTENT DIFF 2.90 (HB 13.85) O2 EXTRACT RATIO 2%
R-TO-L SHUNT 50%+/-3%
A-A GRADIENT 156, A/A 24% (EST ALV PO2 205)
SEVERE HYPOXEMIA BREATHING OXYGEN **CONTACT MD OR RN!!!!

PRELIMINARY INTERPRETATION -- BASED ONLY ON BLOOD GAS DATA.
*** (FINAL DIAGNOSIS REQUIRES CLINICAL CORRELATION) ***
KEY: A=ARTERIAL, V=MIXED VENOUS, C=CAPILLARY, E=EXPIRED CO2, W=WEDGE
CO=CARBOXY HB, MT=MET HB, O2CT=O2 CONTENT, PK=PEAK, PL=PLATEAU, PP=PEEP
MR=MACHINE RATE, SR=SPONTANEOUS RATE
TIME OUT: FEB 03 82 10:11

Fig. 5. Computerized blood gas report. Note key at bottom for explanation of abbreviations used and the disclaimer at the bottom that the computer report is a preliminary interpretation. At the top are the patient identification, the physician, and the room location. The section showing the date is followed by measured and computed values. From left to right are

the acid-base variables, pH, P_{CO_2} , HCO_3 , BE (base excess), and then the oxygen-carrying variables, HB (hemoglobin), CO/MT (carboxyhemoglobin and methemoglobin), PO_2 , SO_2 (saturation), O_2CT (oxygen content), and % O_2 (either the flowrate [<21] or the % oxygen the patient is breathing). The next five columns are for specification of ventilation status, with normal high and low values given for each variable. At 09:41 a venous (V) sample was drawn; at 09:40 an arterial (A) sample was drawn. This was the 51st arterial sample from this patient, whose temperature was 35.2°C and who was on intermittent mandatory ventilation. (Note, however, that the patient took “0” spontaneous breaths [SR].) The indented text is automatically generated by the computer for each arterial sample.

establishment of decision-making criteria for pulmonary function and blood gas data that are readily transferable to other users.*

Despite the concern that the computer might depersonalize medicine, in our hands it has not. On the contrary, our physicians have been able to concentrate their personal skills on caring for the patient and have been relieved of many mundane and tedious computational and bookkeeping tasks. The lack of good decision rules has limited the application of computers in the medical decision-making process. We anticipate that this will change dramatically in the next several years and that computers will find their way into additional aspects of clinical practice.

*Detailed decision-making criteria for pulmonary function and blood gas interpretations are available from the authors for reproduction costs.

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